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Gravitational-wave parameter inference with the Newman-Penrose scalar

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Detection and parameter inference of gravitational-wave signals rely on the comparison between the detector strain data $d(t)$ and the gravitational-wave strain waveform templates $h(t)$. The strain waveform templates ultimately rely on solving the Einstein's equations via numerical relativity simulations. However, the simulations commonly output the Newman-Penrose scalar $\psi_4(t)$ that is related to the strain by $\psi_4(t) = \mathrm{d}^2 h(t)/\mathrm{d}t^2$. Therefore, the obtention of the strain templates involves a double time-integration of the $\psi_4(t)$ that introduces artefacts which need to be eased manually. By taking the second order finite differences on the detector strain data and deriving the corresponding noise statistics, we develop a framework to perform the gravitational-wave data analysis directly using the $\psi_4(t)$ templates. We demonstrate the framework by recovering numerically simulated signals from head-on collisions of Proca stars injected in Advanced LIGO noise, and we show that a significant bias in the parameter estimation could be induced by excessively aggressive filtering of the integration artefacts. Our framework removes the need of the integration process to obtain the strain from the numerical relativity simulations and therefore avoids the associated systematic errors.

Which topic best fits your talk?

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